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APPLICATION FOR UNITED STATES LETTERS PATENT

TITLE: GAS-TO-LIQUIDS FACILITY FOR FIXED OFFSHORE HYDROCARBON PRODUCTION PLATFORMS

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Gas-To-Liquids Facility For Fixed Offshore Hydrocarbon Production Platforms

The present application is based on U.S. Provisional Patent Application No. 60/398,742, which was filed on July 26, 2002.

Background of the Invention

The present invention relates to a method and apparatus for converting natural gas to liquid hydrocarbons for storage and transport. More specifically, the invention relates to such a method and apparatus which are especially suitable for fixed offshore hydrocarbon production platforms.

A large number of fixed offshore hydrocarbon production platforms are currently in operation, all of which produce various quantities of natural gas. At many such sites natural gas is produced in relatively small quantities as a byproduct to the production of oil. When the quantities of this "associated gas" are sufficiently large and the platform is sufficiently close to a gas transportation infrastructure, the gas can be transported to an off-site processing facility.

In the absence of a gas transportation infrastructure, the associated gas is typically disposed of using a variety of methods. One of these methods involves re-injecting the gas into the hydrocarbon formation via a gas injection module located on the platform. Another method entails burning, or flaring, the gas. However, these methods of disposing of the associated gas are wasteful and, in the case of flaring, environmentally unfriendly.

Also, a number of small to medium size gas fields exist which are currently considered "stranded". Stranded fields are those which are located too far from

an existing gas transportation infrastructure to be economically feasible to produce.

As is readily apparent, unprocessed associated gas and stranded gas represent two considerable but untapped sources of hydrocarbons. These sources are not utilized because the transportation of the gas from remote fixed offshore platforms is presently uneconomical. However, the transportation of the gas would be more economically viable if it could first be converted into liquid hydrocarbons, because then it could be transported using the existing oil transportation infrastructure.

Gas-to-liquids ("GTL") technology is commonly employed to convert natural gas to liquid hydrocarbons. The most common GTL process is a two stage process in which the natural gas is first converted into a synthetic gas, or "syngas", and the syngas is then converted into liquid hydrocarbons using the Fisher-Tropsch process. The conversion of natural gas to syngas may be achieved by steam reforming, partial oxidation, or a combination of both. Steam reforming, which is an endothermic process that is performed in a catalytic reactor, typically produces syngas comprising a 3:1 ratio of hydrogen to carbon monoxide. In the Fisher-Tropsch process, which is also carried out in a catalytic reactor, the small hydrocarbon molecules are linked to form longer chain hydrocarbons that are primarily liquid at ambient temperature.

Although GTL technology has been in the public domain since the 1930's, current GTL technology is generally not considered economical at small scales, especially scales suitable for use on fixed offshore hydrocarbon production

platforms. To date, reducing a GTL facility down to the size required to replace an existing gas processing facility and at the same time fit into the confined footprint available on a fixed offshore platform has not been feasible. Previously, any GTL facility which could fit into this limited space typically would not have sufficient processing capacity, that is, it could process only unfeasibly small quantities of natural gas into liquid hydrocarbons.

Summary of the Invention

In accordance with the present invention, these and other disadvantages in the prior art are overcome by providing a GTL facility for a fixed offshore hydrocarbon production platform having a deck which is attached to a base that is secured to the sea floor. The GTL facility comprises a syngas reactor for converting natural gas into syngas and a liquids production unit for converting the syngas into a hydrocarbon liquid. Furthermore, at least one of the syngas reactor and the liquids production unit comprises a catalyst which is constructed using PI micro-reactor technology. As a result, the GTL unit is sufficiently small to be located on the deck of the platform.

In accordance with another embodiment of the invention, the GTL facility further comprises a gas pre-processing unit for converting the natural gas into a form which is suitable for processing by the syngas reactor. For example, the gas pre-processing unit may filter, desulpher and/or dehydrate the natural gas.

In accordance with yet another embodiment of the invention, the GTL facility also comprises a hydrocracker unit for converting the hydrocarbon liquid

into at least one hydrocarbon fuel which may be used to power a device which is located on or near the platform.

The GTL facility of the present invention is small enough to be installed on new or existing fixed offshore hydrocarbon production platforms. In addition, the GTL unit can be installed either in series or in parallel with existing gas processing facilities, such as a gas injection module or a flare. Alternatively, the GTL facility can completely replace the existing gas injection module, the flare, or both.

Thus, the GTL facility of the present invention provides an economical and efficient means for recovering unprocessed associated gas and stranded gas. Since it is sufficiently small to be located on the fixed offshore hydrocarbon production platform, the GTL facility can convert this natural gas into a liquid form which can be readily stored or transported to an off-site processing facility using an existing oil distribution infrastructure. Furthermore, if desired the GTL facility can convert some or all of the natural gas into fuel, such as gasoline, which can be used immediately on or near the offshore platform.

These and other objects and advantages of the present invention will be made apparent from the following detailed description, with reference to the accompanying drawings.

Brief Description of the Drawings

Figure 1 is an elevation view of a typical offshore fixed oil and gas platform;

Figure 2 is a flowchart outlining the processing of the produced fluids on an oil and gas platform utilizing the present invention; and

Figure 3 is a schematic representation of a typical deck layout for an offshore fixed oil and gas platform utilizing the present invention.

Detailed Description of the Preferred Embodiments

The GTL facility of the present invention incorporates Process Intensification ("PI") micro-reactor technology. PI micro-reactor technology involves significantly increasing the ratio of surface area to volume of a catalyst, thus enlarging the percentage of available reaction sites in a given volume of catalyst. Accordingly, PI micro-reactor technology has enabled the development of GTL facilities of dramatically smaller physical size, for example at least one order of magnitude smaller, than prior GTL units having the same capacity. A GTL facility which incorporates PI micro-reactor technology is described in U.S. Patent Application No. [Docket No. 77-12695] filed on May 28, 2003, which is commonly owned herewith and is hereby incorporated herein by reference.

Referring to Figure 1, the preferred embodiment of the present invention comprises a small scale, high throughput PI GTL conversion facility, generally 10, which is installed on a fixed offshore hydrocarbon production platform, such as the exemplary platform 12. The platform 12 comprises a base 14 which is secured to the sea floor 16 and a deck 18 which is connected to the top of the base above the surface of the water. The well fluids which are produced from one or more subsea wells or other sources (not shown) are communicated to the deck 18 via a number of riser pipes 20. These produced fluids are processed in

various processing facilities 22 located on the deck 18, and the resulting oil and/or gas is then typically transported to an on-shore refinery via a pipeline, a shuttle tanker or other conventional means (not shown).

The produced fluids usually include various quantities of oil, natural gas and water. As shown in Figure 2, the produced fluids are therefore typically piped to a conventional separation unit 24, which separates these three main components using techniques that are well understood by those of ordinary skill in the art. After being separated, the water is typically disposed of, the oil is usually stored for subsequent transportation to an on-shore refinery, and the gas is conveyed to a gas processing facility 26.

In the prior art, the associated gas produced with the oil was either flared or re-injected into the formation via a gas injection module. In accordance with the present invention, however, this gas is converted into stable hydrocarbon liquids using the PI GTL facility 10.

The PI GTL facility 10 preferably comprises four basic components: a gas pre-processing unit 28; a syngas reactor 30; a liquids production unit 32; and a hydrocracker unit 34. It should be understood that, depending on the specific requirements of the gas processing facilities of the fixed offshore hydrocarbon production platform, one or more of these components may be eliminated from the present invention.

In the gas pre-processing unit 28, natural gas from the separation unit 24 is conditioned for input into the syngas reactor 32. The gas pre-processing unit 28 thus receives natural gas with potentially wide ranging input properties and

conditions it so that it has characteristics which are uniform and suitable for the syngas reactor 30. In this pre-processing step, the natural gas may undergo, among other operations, filtering, desulphering, dehydrating, liquid propane gas ("LPG") separation, pressure regulation and flow control. The details of these processes are well understood by those of ordinary skill in the art and will therefore not be described in more detail herein. Upon exiting the gas pre-processing unit 28, the conditioned natural gas is comprised primarily of methane.

This conditioned natural gas is then piped to the syngas reactor 30, where it is converted into a syngas mixture comprising a 3:1 ratio of hydrogen to carbon monoxide, or any other gas mixture that is required by the specific GTL process being employed. A suitable process for converting the natural gas into syngas is the steam reforming process in which, as explained more fully in U.S. Patent Application No. [Docket No. 77-12695], the natural gas is mixed with steam and then reacted with a catalyst. The syngas reaction is endothermic, and the heat required to drive the reaction can be supplied by a variety of sources, such as combusting a portion of the natural gas. In a preferred embodiment of the invention, the reaction heat is generated via a catalytic combustion of methane with hydrogen. The hydrogen for this reaction may be recycled from the residual, or "tail", gas produced in the liquids production unit 32.

The syngas reactor 30 ideally comprises a number of catalysts which are constructed using PI micro-reactor technology. For example, each such catalyst may comprise a reticulated ceramic foam catalyst containing one or more metal oxides of chromium, cobalt, nickel or the like. An example of this type of catalyst

is described in U.S. Patent Application Publication No. 2002/0009407 A1, which is hereby incorporated herein by reference.

In the liquids production unit 32, the syngas or other output gas mixture from the syngas reactor 30 is converted into a mixture of higher chain hydrocarbon molecules, preferably C_5+, which are primarily liquid at ambient temperature. Ideally, this conversion is accomplished using the Fischer-Tropsch method, but other polymerization methods may also be used.

In a preferred embodiment of the invention, the liquids production unit 32 comprises a number of catalysts which are constructed using PI micro-reactor technology. As described in U.S. Patent No. 6,211,255, which is hereby incorporated herein by reference, such a catalyst may comprise an inactive substrate having plurality of channels formed therein which are coated with a Fisher-Tropsch catalyst and through which the syngas is permitted to flow.

The hydrocarbon liquids produced in the liquids production unit 32 can be stored on the platform 12 or transported immediately to an off-site facility for further processing. Alternatively, and in accordance with another feature of the present invention, the liquids can be input to the hydrocracker unit 34.

In the hydrocracker unit 34, the stable hydrocarbon liquids from the liquids production unit 32 are converted into hydrocarbon fuels, such as diesel, gasoline or any other desired fuel. The techniques used to effect such conversions are readily understood by those of ordinary skill in the art. As a result of the conversion of the hydrocarbon liquids into fuels, the fuels may be used immediately on or near the platform 12 or transported to an off-site facility.

Referring to Figure 3, the PI GTL facility 10 may be located in an area of the platform 12 designated by the number 36. On a typical fixed platform, area 36 would normally be occupied by a gas injection module. In the preferred embodiment of the invention, the gas injection module and/or the flare are completely replaced by the PI GTL facility 10 in a retrofit operation. Therefore, the PI GTL facility 10 ideally must be able to fit into the existing area 36 and must have the capacity to process the same volume of gas as the gas injection module and/ore the flare. Alternatively, the PI GTL facility 10 could be incorporated into a new fixed platform design.

It should be recognized that, while the present invention has been described in relation to the preferred embodiments thereof, those skilled in the art may develop a wide variation of structural and operational details without departing from the principles of the invention. Therefore, the appended claims are to be construed to cover all equivalents falling within the true scope and spirit of the invention.